King's Research Portal

DOI:
10.2334/josnusd.16-0135

Document Version
Peer reviewed version

Link to publication record in King's Research Portal

Citation for published version (APA):
Carvalho, P. M., Castelo, P. M., Carpenter, G., & Gavião, M. B. D. (2016). Masticatory function, taste, and salivary flow in young healthy adults. *JOURNAL OF ORAL SCIENCE*, *58*(3), 391-399. https://doi.org/10.2334/josnusd.16-0135

Citing this paper
Please note that where the full-text provided on King's Research Portal is the Author Accepted Manuscript or Post-Print version this may differ from the final Published version. If citing, it is advised that you check and use the publisher's definitive version for pagination, volume/issue, and date of publication details. And where the final published version is provided on the Research Portal, if citing you are again advised to check the publisher's website for any subsequent corrections.

General rights
Copyright and moral rights for the publications made accessible in the Research Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognize and abide by the legal requirements associated with these rights.

•Users may download and print one copy of any publication from the Research Portal for the purpose of private study or research.
•You may not further distribute the material or use it for any profit-making activity or commercial gain
•You may freely distribute the URL identifying the publication in the Research Portal

Take down policy
If you believe that this document breaches copyright please contact librarypure@kcl.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

Download date: 05. May. 2023

Masticatory function, taste and salivary flow in young healthy adults

Polliane M Carvalho [a]

Paula M Castelo [b]

Guy H Carpenter [c]

Maria Beatriz D Gavião [d]

[a] Department of Morphology – Piracicaba Dental School - University of Campinas (UNICAMP), Piracicaba, Brazil.

[b] Department of Biological Sciences – Federal University of São Paulo (UNIFESP), Diadema, Brazil

[c] Department of Salivary Research - King's College London

[d] Department of Pediatric Dentistry – Piracicaba Dental School - University of Campinas (UNICAMP), Piracicaba, Brazil.

Corresponding author:

Prof. Maria Beatriz Duarte Gavião

Department of Pediatric Dentistry

FOP-UNICAMP

Av. Limeira n° 901- CP 52

Piracicaba-SP-CE: 1314-903

Email: mbgaviao@fop.unicamp.br

ABSTRACT

Masticatory function, taste and saliva are important predictors of oral health.

Purpose: The aim of this study was to investigate masticatory function and taste and their possible relationship with salivary flow in young adults with good oral health. Furthermore, the study examined whether anthropometric measurements and gender could influence the variables studied. **Materials and methods:** One hundred seventy subjects were selected (♀125, ♂46). Masticatory performance was evaluated with the sieve method. Masticatory ability was measured using the visual analogue scale (VAS). Taste was evaluated using the drop test with four different flavors in three different concentrations. Unstimulated (Unst) and stimulated (Stim) saliva flows were measured. The anthropometric variables measured were body mass index (BMI) and waist circumference (WC). **Results:** The independent variables studied could not predict masticatory performance. The independent variables BMI, WC and gender predicted 14% of masticatory ability. BMI predicted 5% of taste. **Conclusion:** Masticatory performance was not related to salivary flow or anthropometric parameters in young healthy adults. Masticatory ability was related to BMI, WC and gender, and taste was weakly related to BMI. The flow rate did not present a statistically significant difference between males and females for the anthropometric groups.

Keywords: masticatory performance; BMI; Salivary flow; Taste

INTRODUCTION

A sufficient amount of saliva is important for appropriate masticatory function (1). Salivary secretion is mainly induced during eating, and the perception of food texture is mediated by saliva (2). Taste is also influenced by saliva through the distribution of taste substances to taste receptors, chemical interactions with taste substances and alterations in the sensitivity of taste receptors (3). Saliva is an important agent in oral physiology (4). Most saliva is produced by three pairs of major glands: the parotid, submandibular and sublingual glands (5). The flow and quality of saliva are important indicators of oral health.

Masticatory function can be objectively evaluated using comminution tests, which measure the individual's capacity to break down foods into particles in a specific number of chewing cycles by determining the sizes of test food samples that have been chewed (6;7). Another method for verifying masticatory function is subjective tests that measure the subject's own perception of chewing, such as the ability test (8,9).

Taste is the sensory impression of food or other substances on the tongue. It is characterized as one of the five traditional senses, and it can be associated with food preferences (10,11). The taste receptors on tongue are constantly bathed with saliva, which modulates a significant number of physiological processes. It has been reported that changes in taste are related to oral health factors such as dry mouth, tongue coating and the loss or destruction of taste receptors (12). Furthermore, associations among oral conditions and anthropometric measures, such as body mass index (BMI), have been identified in previous studies (13,14). Studies also report poor oral health in obese people (14). Sex-related differences are another important variable to study because sex hormones could influence salivary glands, taste perception and muscle activity for mastication (15-17).

Considering the importance of masticatory function and taste and the role of saliva in these parameters, it is relevant to evaluate the relationships among them. Additionally, studies of the influence of gender and anthropometric measurements on those factors are highly recommended to provide a basis for further studies. Saliva and chewing have been shown to be interrelated; nevertheless, the relationship between the amount of saliva and masticatory function has not been fully elucidated (18). There are previous data regarding this association in older individuals (19) and children (20), but studies of young healthy adults are scarce. Thus, the aim of this study was to investigate the relationships among masticatory function and taste and salivary flow rate in young adults. Furthermore, the study examined whether gender and anthropometric measurements could be influenced by the studied variables.

MATERIALS AND METHODS

Sample

The study included a convenience sample of 171 subjects aged 18 to 33 years (125 females, 46 males) selected from public or private schools of higher education in Piracicaba, SP, Brazil. Both undergraduate and postgraduate students participated after they signed the informed consent form. The study was approved by the Ethics Committee of Piracicaba Dental School (Protocol number 110/2011).

Clinical Examination

A clinical examination was performed to verify the normality of the oral tissues and the absence of tooth loss; occlusion was also checked to ensure that all participants had a normal occlusion, i.e., the first permanent molars in Angle's Class 1, a normal relationship between the canines and an overjet and overbite less than or equal to 3 mm. These oral characteristics comprised the inclusion criteria. The exclusion criteria were the use of dental appliances, systemic illness, smoking, and the ingestion of medicines that could affect the central nervous system, muscular activity, or salivary secretion.

Physical Evaluation

The anthropometric measurements included body weight (kg) and height (m), which were used to determine the body mass index (BMI), and waist circumference (WC) (cm).

All measurements were made according to international standards (21). Body weight and height were obtained using an anthropometric scale (110CH, Welmy, Santa Bárbara D'Oeste, SP, Brazil) with an accuracy of 100 g and a stadiometer with an accuracy of 0.5 cm. BMI was calculated as BMI=kg/m^2. Furthermore, the following World Health Organization cut-offs for BMI were used: underweight<18.5 kg/m^2, normal weight from 18.5 kg/m^2 to 24.9 kg/m^2, overweight$\geq$25 kg/m^2, obese$\geq$30 kg/m^2 (22).

For the waist circumference measurement, a flexible tape measure (ES4010, Sanny anthropometric tape 2.0 m, American Medical Brazil, Ltd., São Paulo, Brazil) was used while the volunteers stood upright. The tape was placed at the narrowest point between the xiphoid process and the iliac crest (23).

Masticatory Performance

Masticatory performance was assessed by determining the individual's capacity for the fragmentation of a chewable test material called Optocal (24) composed of silicon OptosilR plus, 58.3%; toothpaste, 7.5%; solid Vaseline, 11.5%; common dental plaster powder, 10.2%; alginate powder, 4%; and catalyst paste, 20.8 mg/g). The components were blended and placed in metal molds with cubic compartments measuring 5.6 mm, and mechanical pressure was applied. The subjects received 17 cubes (3.6 g) and chewed them for 20 masticatory cycles, which were monitored visually by the examiner. The fragmented particles were then expelled from the oral cavity into plastic receptacles covered with filter paper. After drying, the particles were weighed and passed through a series of 10 granulometric sieves with meshes ranging from 0.71 to 5.60 mm, connected in decreasing order and closed with a metal base. The particles were placed in the first sieve in the series, and the set was vibrated for 20 min. The particles retained on each sieve were removed and weighed on an analytical scale

with a precision of 0.001 g. The distribution of the particles by weight was described using a cumulative function (Rosim-Ramler equation). The degree of fragmentation of the material was then described by the median particle size (X50), which was the aperture of the sieve through which 50% of the weight of the fragmented material could theoretically pass (25):

$$QW(X)=1-2(X/X50)^{b}$$

In this formula, QW is the weight fraction of particles that are smaller than X. The variable “b” represents the spread of the size distribution (broadness variable), reflecting the extent to which the particles were equally sized.

Masticatory Ability

Self-perceived chewing ability consists of the individual's perception of his or her ability to grind food. This variable was measured using the visual analogue scale (VAS) (26), which consists of a horizontal line, with extremes marked 0 and 10, corresponding to the classification "completely dissatisfied" (point 0) and "fully satisfied" (point 10). The volunteers were asked "How satisfied are you with your ability to chew food?" (9) and prompted to mark the point on the line that corresponds to his or her level of satisfaction.

Taste

To evaluate flavor thresholds, a modified methodology proposed by Mueller et al. was used (27). Four liquid solutions were used in three different concentrations: sweet, 0.2, 0.1, and 0.05 g/ml of sucrose; sour, 0.165, 0.09, and 0.05 g/ml of citric acid; salty, 0.1, 0.04, and 0.016 g/ml of sodium chloride; bitter, 0.0024, 0.0009, and 0.0004 g/ml of quinine hydrochloride. Two drops of liquid were placed on the middle of the tongue approximately 1.5 cm from the tip using a dropper; the subjects were allowed to close their mouths. The sequence of administration was randomized across trials. For each test, the participant chose one of the four options: sweet, salty, bitter or acid (sour). There was no limit time for the test. The tests started with the lowest concentration. The subjects' task was to identify the correct taste. Between each test, the participants rinsed their mouths with a sip of tap water. Each correct taste was given a value of "1". The result for the entire test was the sum of the results for the individual taste qualities (range 0 to 12).

Salivary Flow

The following parameters were considered: Stimulated and unstimulated salivary flow rate.

Saliva Collection

Stimulated and unstimulated saliva were collected in the morning, and all subjects were asked to refrain from eating, drinking or brushing their teeth for at least 2 h before collection. The subjects were comfortably seated, and after a few minutes of relaxation, they rinsed their mouths with distilled water. For the unstimulated saliva flow measurement, they were asked to avoid swallowing their saliva and to lean forward and spit all of the saliva they produced over a 5-min period through a glass funnel into a cooled tube. After that, stimulated saliva was collected for 5 min by having the participants chew 0.3 g of an inert and tasteless material (Parafilm, Merifeld, EUA) for approximately 70 cycles/min. The stimulated and unstimulated flow rates were defined as the weight of the saliva secreted per min (g/min).

Statistics

The collected data were analyzed using SPSS software (SPSS 21.0, Inc., Chicago, IL, USA). Descriptive statistics were used for all variables, including means, medians, standard and interquartile deviations and frequency. The normality of the data was checked using the Shapiro-Wilk test. The data for males and females were compared using the *t* test, Mann-Whitney and Wilcoxon tests. Chi-squared or Fisher's exact tests were used to compare proportions among groups, and Spearman's coefficients were determined to correlate masticatory function, taste and unstimulated and stimulated salivary flow rate. Furthermore, to verify the possible factors associated with masticatory function and taste, three models of multiple linear regression analyses were built. Thus, masticatory performance, ability, and taste were entered into the models as dependent variables, and age, gender, BMI, waist circumference, and unstimulated and stimulated salivary flow rate were entered as the independent variables. First, a bivariate analysis was conducted between the dependent variables and the independent ones.

Only variables with $p \leq 0.20$ for the bivariate linear regression were kept in the multivariable models as potential confounders. A significance level of 5% was adopted.

RESULTS

The characteristics of the samples are presented in Table 1. The number of females was significantly higher than the number of males. In terms of anthropometry, the proportion of underweight females was significantly higher than the proportion of underweight males, whereas the proportion of obese males was greater than the proportion of obese females. The anthropometric variables, BMI and waist circumference, were significantly higher for the males, as expected. Masticatory function, taste and salivary flow were similar between genders.

Table 1 – Sample characteristics

			♂	♀	Total	
	Gender		46 (26.90%)	125 (73.10%)	171 (100%)	*P*<0.0001 (χ^2)
	Age (years)	Mean±SD	23.46±4.10	23.89±4.87	23.77±4.67	*P*=0.76 (t test)
		Median[ID]	22.50[5.75]	23.00[6.00]	23.00[6]	
Masticatory function and taste parameters	X50 (mm)	Mean±SD	3.45±0.57	3.46±0.75	3.46±0.70	*P*=0.93 (t test)
		Median[ID]	3.42[0.87]	3.38[0.83]	3.39[0.87]	
	Ability	Mean±SD	8.26±1.39	7.83±1.43	7.94±1.43	*P*=0.079 (t test)
		Median[ID]	8.00[1.75]	8.00[2]	8.0[2]	
	Taste	Mean±SD	11.30±1.07	11.30±1.27	11.30±1.22	*P*=0.99 (t test)
		Median[ID]	12.00[1]	12.00[1]	12.00[1]	
Unstimulated saliva	Flow rate (g/min)	Mean±SD	0.80±0.37	0.76±0.29	0.77±031	*P*=0.51 (t test)
		Median[ID]	0.75[0.40]	0.73[0.36]	0.73[0.39]	
Stimulated saliva	Flow rate (g/min)	Mean±SD	1.54±0.52	1.52±0.74	1.52±0.69	*P*=0.84 (t test)
		Median[ID]	1.55[0.70]	1.42[0.54]	1.42[0.59]	
Anthropometry	BMI	Mean±SD	24.80±4.96	22.04±3.85	22.78±4.34	*P*=0.0002 (t test)
		Median[ID]	23.83[4.97]	21.30[4.48]	22.00[5]	
	WC (cm)	Mean±SD	85.76±11.88	73.28±8.79	76.64±11.16	*P*<0.0001 (Mann-Whitney)
		Median[ID]	83.50[9.00]	72.00[11.00]	75.00[13.25]	
	Underweight	n (%)	2 (9.10)	20 (90.90)	22 (100)	0.043 (Fisher)
	Normal weight	n (%)	24 (22.42)	83 (77.57)	107 (100)	0.127 (χ^2)
	Overweight	n (%)	13 (43.33)	17 (56.66)	30 (100)	0.063 (χ^2)
	Obese	n (%)	7 (58.33)	5 (41.66)	12 (100)	0.018 (Fisher)

Flow rate - ♂ n= 42; ♀ n=124 (the saliva samples of 5 individuals were missing)
SD – standard deviation
ID – interquartile deviation
BMI – body mass index
WC – waist circumference

The correlations between masticatory function, taste, and salivary flow were not significant. The correlation between unstimulated and stimulated salivary flow was significant: $r=0.54$, $p<0.01$ (Table 2).

Table 2 – Correlation matrix for masticatory function, taste and salivary flow

N=171	X50	Ability	Taste	Flow unst	Flow stim
Ability	-0.08	___			
Taste	-0.05	-0.06	___		
Flow unst	0.03	-0.05	0.05	___	
Flow stim	0.05	-0.28	-0.09	0.54**	___

Flow unst –unstimulated salivary flow rate
Flow stim – stimulated salivary flow rate

** Pearson coefficients $P<0.01$

Comparisons of masticatory function, taste and salivary flow rate according to anthropometric status showed no significant differences. However, in the obese group, the stimulated flow rate did not correlate with the unstimulated rate, whereas for the other three groups, the coefficients were significant. Moreover, the flow rate did not present a statistically significant difference between males and females for any of the groups (Table 3).

Table 3 - Descriptive statistics for the salivary flow of the studied groups (mean±SD)

	Underweight			**Normal weight**			**Overweight**			**Obese**		
	♂	♀	Total	♂	♀	Total	♂	♀	Total	♂	♀	Total
Flow unst (g/min)	0.76 ±0.56	0.68 ±0.22	0.70 ±0.28	0.80 ±0.36	0.78 ±0.30	0.75 ±0.42	0.86 ±0.41	0.76 ±0.32	0.69 ±0.44	0.70 ±0.18	0.53 ±0.20	0.62 ±0.20
Flow stim (g/min)	1.28 ±0.26	1.37 ±0.60	1.38 ±0.57	1.49 ±0.49	1.56 ±0.82	1.42 ±0.62	1.58 ±0.61	1.47 ±0.45	1.51 ±0.70	1.77 ±0.43	1.34 ±0.24	1.57 ±0.44
Flow stim x unst	r=0.42* *P*=0.02			r=0.60* *P*=0.00			r=0.66* *P*=0.00			r=0.13 *P*=0.69		

*Pearson/Spearman coefficients *P*<0.05*
Flow unst –unstimulated salivary flow rate
Flow stim - stimulated salivary flow rate
t test/Mann-Whitney tests comparing males and females for each group: *P* >0.05

A bivariate analysis (Table 4) was performed to select the independent variables that were eligible for inclusion in the regression model (i.e., the variables with a *P* value≤0.20). Masticatory performance was not predicted by the independent variables. Gender, age, BMI and waist were eligible for the multiple regression for the dependent variable ability, whereas for taste, the variables BMI and waist were eligible for the multiple regression. For ability, the multiple model was significant, and the independent predictive variables were gender, BMI, and waist (Table 5). For taste, the model was also significant, and the predictor was BMI (Table 6).

Table 4 – Bivariate analysis for masticatory function and taste parameters

Dependent	X50			Ability			Taste		
	r	Adj. r^2	*P*	r	Adj. r^2	*P*	r	Adj. r^2	*P*
Independent									
Gender	0.006	-0.006	0.942	0.127	0.010	0.098	0	-0.006	0.999
Age	0.113	0.007	0.142	0.205	0.036	0.007	0.075	0	0.327
BMI	0.037	-0.005	0.629	0.179	0.026	0.019	0.216	0.041	0.005
WC	0.023	-0.005	0.771	0.185	0.029	0.016	0.147	0.016	0.056
Flow unst	0.130	-0.006	0.864	0.051	-0.004	0.516	0.082	0.001	0.293
Flow stim	0.003	-0.006	0.965	0.030	-0.005	0.704	0.006	-0.006	0.936

BMI – body mass index

WC – waist circumference
Flow unst –unstimulated salivary flow rate
Flow stim – stimulated salivary flow rate
Adj. r^2 – adjusted r^2

The coefficient of determination (R) obtained from a regression analysis indicates how well the data fit a statistical model. The adjusted R^2, which is more reliable when extra explanatory variables are added to the model, was chosen to determinate the percentages of ability and taste that were predicted by the independent variables. Regarding masticatory ability, 14% by was predicted by the independent variables BMI, waist circumference and gender. Regarding taste, 5% was predicted by BMI.

Table 5 – Multiple linear regression analysis for masticatory ability

Independent variable	ß	SE	b	*P* value
Constant	-	1.083	13.884	<0.001
Gender	-0.407	0.289	-1.265	<0.001
Age	-0.084	0.021	-0.024	0.257
BMI	0.577	0.058	0.190	0.001
WC	-0.896	0.025	-0.114	<0.001

Dependent variable: ability.
ß signifies an unstandardized partial regression coefficient.
b signifies a standardized partial regression coefficient, which indicates the relative importance of each variable.
BMI – body mass index.
WC – waist circumference

Multiple R = 0.40, adjusted R^2 = 0.14, *P*=0.00.
Gender: female = 1, male = 0.

Table 6 – Multiple linear regression analysis for taste

Independent variable	ß	SE	b	*P* value
Constant	-	0.675	12.090	<0.001
BMI	-0.441	0.049	-0.128	0.010
WC	0.248	0.019	0.028	0.144

Dependent variable: taste.

ß signifies an unstandardized partial regression coefficient.

b signifies a standardized partial regression coefficient, which indicates the relative importance of each variable.

Multiple R = 0.24, adjusted R^2 = 0.049, *P*=0.006.

BMI – body mass index.

WC – waist circumference

DISCUSSION

The aim of this study was to investigate masticatory function and taste and their possible relationship with salivary characteristics in young adults. Furthermore, the study examined whether anthropometric measurements and gender had an influence on the variables studied. The study sample was composed of young dentate adults with good oral health. The sample included a greater number of females than males, but the ages were similar between gender groups. Masticatory performance was evaluated using the sieve method, which is considered the standard method for evaluating masticatory function (28). The median X50 value found in the present study, 3.39 mm, can be considered good, in agreement with previous studies (6,7) and similar between genders, as previously reported (6,29). Nevertheless, no distinct findings between genders are clearly stated because some studies have found a better performance for males (17,30). The masticatory ability values could indicate that the volunteers rated their ability confidently. This fact could be explained by the participants' good oral health and presence of all teeth. Similarly, Zhang et al.(31) verified that chewing ability was strongly associated with dental conditions, adding that subjects with tooth replacement had a higher likelihood of chewing problems. Interestingly, although the masticatory performance and ability values in the present study indicated adequate masticatory function, the respective correlations were not significant, probably because of the nature of the tests. Functional tests, such as the comminution test, more directly estimate an individual's mechanical chewing function because they based on objective parameters; however, they may not correlate well with an individual's own perception of his/her chewing ability (32).

Regarding taste, the subjects distinguished the flavor and respective concentrations very well, as indicated by the large ceiling effect and the absence of a floor effect. Ceiling effects exist when a score reaches a maximum extreme, while floor effects exist when a score reaches a minimum extreme. Only one female presented a score of “3”, indicating taste hyposensitivity, and one other female had a score “6”, indicating moderate taste hyposensitivity. The other participants scored above “8”.

Regarding gender, the statistics tests did not reveal significant differences. Consistent with our results, Ohnuki et al.(33) studied students aged 15–18 years and found no significant differences in taste hyposensitivity between genders; however, some authors suggest that gender hormonal variations can influence taste perception (34). This inconsistency may indicate the need for a more sensitive taste test for use in large samples. Taste was not correlated with masticatory function parameters. As noted above, the nature of the tests could be an influencing factor. In this context, it is important to incorporate the broader biological and sociological aspects of eating habits and taste sensations that are involved in diet choice into further studies of taste, as suggested by Ohnuki et al.(35).

In the present study, the unstimulated and stimulated salivary flow rates were similar between males and females. This finding is consistent with Smith et al.(36), who observed that the effect of sex was not significant for stimulated saliva. Nevertheless, Yamamoto et al.(37) affirmed that the total saliva flow rate of an individual should only be compared with data from those of the same gender. The different findings might be explained by differences in methodology, such as the period of saliva collection and stimulus type.

A correlation among salivary flow rate, masticatory function and taste parameters was expected because saliva is an important agent in oral physiology (4). However, the respective coefficients were very low. This finding is quite interesting given that our study group, which comprised young adults, presented the same results that Ikebe et al.(19) observed in health older adults; however, they found significant correlations in people without posterior occlusal support (38). This might indicate that age *per se* is not the determinant factor in the association between saliva and masticatory function and that other aspects, such as the remaining number of teeth, could influence this association.

It has been observed that oral conditions may be associated with anthropometric measurements (14,39). In this context, a high BMI has been associated with hyposalivation (40). Our results revealed that salivary flow rates were not correlated with anthropometric values. We also observed that only in the obese group was the unstimulated saliva flow rate uncorrelated with the rate after mechanical stimulation. However, these findings should be interpreted with caution because of the small number of obese individuals in our sample.

The bivariate analysis showed that masticatory performance was not associated with the independent variables; thus the regression model could not be built. Gender and anthropometric measurements could explain 14% of masticatory ability. Consistent with our results, Ostberg et al.(14) consider masticatory ability may have others factors (physical, social and psychological) that could explain understand this variable's behavior among individuals. Gender presented a negative relationship in our data, which indicates that males perceived themselves as chewing better. This may be related to the fact that women are usually more worried about their health and might evaluate their chewing more critically. However, this finding should be interpreted with caution because of the preponderance of females in the sample. According to the results of the third regression model, BMI and waist circumference WC could explain 5% of taste. Obesity has been linked to diets containing high levels of fat and sugar, which may have implications for taste conditions (41,42); however, Donaldson et al.(43) argue that taste is only one factor among the complex causes of obesity and overweight, which corroborate with the percentage of taste predicted in our results.

Finally, it is possible to infer that in healthy young individuals, masticatory function and taste were considered adequate. Moreover, the salivary flow rate was normal for all subjects, probably indicating proper function, although no association was observed. The anthropometric measures had little influence on the studied variables. Nevertheless, some limitations must be noted, such as the greater number of females. These limitations indicate that the results should be interpreted with caution for other populations, although all clinical data were collected under standardized conditions. Moreover, the cross-sectional nature of this study does not permit conclusions about causal relationships.

CONCLUSION

Masticatory function and taste were weakly related to salivary flow in young healthy adults. Masticatory ability was related to BMI, waist circumference and gender, and taste was weakly related to BMI. Masticatory function, taste and salivary flow were similar between genders in young healthy individuals. The flow rate did not present a statistically significant difference between males and females for the anthropometric groups.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the financial support of the São Paulo Research Foundation (FAPESP) (Process 2012/06179-0), the scholarship for the first author (Process 2011/08715-3), and the participants.

REFERENCES

1. Gavião MB, Bilt AV (2004) Salivary secretion and chewing: stimulatory effects from artificial and natural foods. J Appl Oral Sci 12, 159-63.

2. van der Bilt A, Engelen L, Pereira LJ, van der Glas HW, Abbink JH (2006) Oral physiology and mastication. Physiol Behav 89, 22-27.

3. Mese H, Matsuo R (2007) Salivary secretion, taste and hyposalivation. J Oral Rehabil 34, 711-723.

4. Chiappin S, Antonelli G, Gatti R, De Palo EF (2007) Saliva specimen: a new laboratory tool for diagnostic and basic investigation. Clin Chim Acta 383,30–40.

5. Carpenter GH (2013) The secretion, components, and properties of saliva. Annu Rev Food Sci Technol 4, 267-276.

6. van der Bilt, Fontijn-Tekamp FA (2004) Comparison of single and multiple sieve methods for the determination of masticatory performance. Arch Oral Biol 49, 193–198.

7. Sánchez-Ayala A, Vilanova LS, Costa MA, Farias-Neto A (2014) Reproducibility of a silicone-based test food to masticatory performance evaluation by different sieve methods. Braz Oral Res 28, 1-8.

8. Miura H, Kariyaasu M, Yamasaki K, Arai Y, Sumi Y (2005) Relationship between general health status and the change in chewing ability: a longitudinal study of the frail elderly in Japan over a 3-year period. Gerodontology 22, 200–205.

9. Bradbury J, Thomason JM, Jepson NJ, Walls AW, Mulvaney CE, Allen PF, Moynihan PJ (2008) Perceived chewing ability and intake of fruit and vegetables. J Dent Res 87, 720-725.

10. Dressler H, Smith C (2013) Food choice, eating behavior, and food liking differs between lean/normal and overweight/obese, low-income women. Appetite 65, 145-152.

11. Barretto RP, Gillis-Smith S, Chandrashekar J, Yarmolinsky DA, Schnitzer MJ, Ryba NJ, Zuker CS (2014) The neural representation of taste quality at the periphery. Nature 15, 373-376.

12. Bromley SM (2000) Smell and taste disorders: a primary care approach. Am Fam Physician 61, 427-438.

13. Mathus-Vliegen EM, Nikkel D, Brand HS (2007) Oral aspects of obesity. Int Dent J 57, 249–256.

14. Östberg AL, Bengtsson C, Lissner L, Hakeberg M (2012). Oral health and obesity indicators. BMC Oral Health 20, 12-50.

15. Prodan A, Brand HS, Ligtenberg AJ, Imangaliyev S, Tsivtsivadze E, van der Weijden F, Crielaard W, Keijser BJ, Veerman EC (2015) Interindividual variation, correlations, and sex-related differences in the salivary biochemistry of young healthy adults. Eur J Oral Sci 123, 149-157.

16. Landis BN, Welge-Luessen A, Brämerson A, Bende M, Mueller CA, Nordin S, Hummel T 2009 "Taste Strips" - a rapid, lateralized, gustatory bedside identification test based on impregnated filter papers. J Neurol 256, 242-248.

17. Shiga H, Kobayashi Y, Katsuyama H, Yokoyama M, Arakawa I (2012) Gender difference in masticatory performance in dentate adults. J Prosthodont Res 56, 166-169.

18. Hector MP, Linden RWA (1999) Reflexes of salivary secretion. In: Garrett JR, Ekström J, Anderson LC, editors. Neural mechanisms of salivary gland secretion. Basel: Karger. 196-217.

19. Ikebe K, Matsuda K, Kagawa R, Enoki K, Yoshida M, Maeda Y, Nokubi T (2011) Association of masticatory performance with age, gender, number of teeth, occlusal force and salivary flow in Japanese older adults: is ageing a risk factor for masticatory dysfunction? Arch Oral Biol 56, 991-996.

20. de Morais Tureli MC, de Souza Barbosa T, Gavião MB (2010) Associations of masticatory performance with body and dental variables in children. Pediatr Dent. 32,283-288.

21. Gordon CC, Chumlea WC, Roche AF. Stature, recumbent length, weight. In: Lohman TG, Roche AF, Martorell R 1991 editors. Anthropometric standardizing reference manual. Champaign, Illinois: Human Kinetics Books 3-8.

22. World Health Organ Tech Rep Ser (2000) Obesity: preventing and managing the global epidemic. Report of a WHO consultation. 894, 1-253.

23. Guerra RS, Amarai TF, Marques EA, Mota J (2012) Restivo MT.Anatomical location for waist circumference measurement in older adults; a preliminary study. Nutr. Hosp. 27, 1554-1561.

24. Slagter AP, Bosman F, van der Glas HW, van der Bilt A (1993) Human jaw-elevator muscle activity and food comminution in the dentate and edentulous state. Arch Oral Biol 38, 195-205.

25. van der BiltA, Olthoff LW, Bosman F, Oosterhaven SP (1994) Chewing performance before and after rehabilitation of post-canine teeth in man. J Dent Res 73, 1677-1683.

26. Awad MA, Lund JP, Shapiro SH, Locker D, Klemetti E, Chehade A, Savard A, Feine JS (2003) Oral health status and treatment satisfaction with mandibular implant overdentures and conventional dentures: a randomized clinical trial in a senior population. Int J Prosthodont 16, 390-396.

27. Mueller C, Kallert S, Renner B, Stiassny K, Temmel AF, Hummel T, Kobal G (2003) Quantitative assessment of gustatory function in a clinical context using impregnated “taste strips”.Rhinology 41, 2-6.

28. Oliveira Junior NM, Shaddox LM, Toda C, Paleari AG, Pero AC, Compagnoni MA (2014) Methods for evaluation of masticatory efficiency in conventional complete denture wearers: a systematized review. Oral Health Dent Manag 13, 757-762.

29. Ikebe K, Matsuda K, Morii K. Furuya-Yoshinaka M, Nokubi T Renner RP (2006) Association of masticatory performance with age, posterior occlusal contacts, occlusal force, and salivary flow in older adults. Int J Prosthodont 19, 475-481.

30. Julien KC, Buschang PH, Throckmorton GS, Dechow PC (1996) Normal masticatory performance in young adults and children. Arch Oral Biol 41, 69–75.

31. Zhang Q, Witter DJ, Bronkhorst EM, Creugers NH (2013). Chewing ability in an urban and rural population over 40 years in Shandong Province, China. Clin Oral Investig 17, 1425-1435.

32. Meng X, Gilbert GH (2007). Predictors of change in satisfaction with chewing ability: a 24-month study of dentate adults. J Oral Rehabil 34, 745-758.

33. Ohnuki M, Shinada K, Ueno M, Zaitsu T, Wright FA, Kawaguchi Y (2012) Exploring taste hyposensitivity in Japanese senior high school students. J Investig Clin Dent 3,23-29.

34. Duffy VB, Bartoshuk LM (2000) Food acceptance and genetic variation in taste. J Am Diet Assoc 100, 647-655.

35. Ohnuki M, Ueno M, Zaitsu T, Kawaguchi Y (2014) Taste hyposensitivity in Japanese school children. BMC Oral Health 11,14-36.

36. Smith CH, Boland B, Daureeawoo Y, Donaldson E, Small K, Tuomainen J (2013) Effect of aging on stimulated salivary flow in adults. J Am Geriatr Soc 61, 805-808.

37. Yamamoto K, Kurihara M, Matsusue Y, Imanishi M, Tsuyuki M, Kirita T (2009) Whole saliva flow rate and body profile in healthy Young adults. Arch Oral Biol 54, 464-469.

38**.** Ikebe K, Matsuda K, Kagawa R, Enoki K, Okada T, Yoshida M, Maeda Y (2012) Masticatory performance in older subjects with varying degrees of tooth loss. J Dent. 40, 71-76.

39**.** Benguigui C, Bongard V, Ruidavets JB, Sixou M, Chamontin B, Ferrières J, Amar J 2012 Evaluation of oral health related to body mass index. Oral Dis 18, 748-755.

40. Saito T (2009) Hyposalivation is Associated with High BMI Among Young Adults and is Associated with Medication in Older Adults in Sweden. J Evid Based Dent Pract 9, 242-243.

41. Simchen U, Koebnick C, Hoyer S, Issanchou S, Zunft HJ (2006) Odour and taste sensitivity is associated with body weight and extent of misreporting of body weight. Eur J Clin Nutr 60, 698–705.

42. Bartoshuk LM, Duffy VB, Hayes JE, Moskowitz HR, Snyder DJ (2006) Psychophysics of sweet and fat perception in obesity: problems, solutions and new perspectives. Philos Trans R Soc Lond B Biol Sci 29, 1137-1148.

43. Donaldson LF, Bennett L, Baic S, Melichar JK (2009) Taste and weight: is there a link? Am J Clin Nutr 90, 800-803.